Differential Susceptibility to Fire Blight in Commercial and Experimental Apple Rootstock Cultivars

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Abstract

The Geneva rootstock breeding program has developed several new rootstocks that exhibit disease resistance to *Erwinia amylovora*. Utilization of disease resistant apple rootstocks increases the survivability of young trees infected by fire blight. The goal of this experiment was to further investigate the possibility of differential susceptibility of numerous commercial and experimental apple rootstock varieties to four diversely virulent strains of *E. amylovora* (E2002a, E4001a, E2017, and Ea273). Ungrafted potted rootstock liners were inoculated with the bacteria and the resultant necrotic lesions were used as an indication of susceptibility. Results showed that the *E. amylovora* strain E2002a was the most aggressive, followed by E4001a. E2017a and Ea273 were similar and less aggressive. The six rootstocks with greatest severity of infection in descending order were 'MM.106', 'Supporter 4', 'M.9', 'M.26', 'B.118', and 'B.9'. In this experiment B.9 had less severe infection than 'M.9' and 'M.26', in contrast with a previous experiment by Norelli et al. (2000). Most selections from the Geneva breeding program had little infection by strains E2017 and Ea273 and moderate infection by strains E2002a and E4001a. Most screenings for fire blight resistance in the seedling progenies of the Geneva® rootstocks employed only strain Ea273. 'Geneva® 3041', '7707', and '5179' and 'Geneva®16', had least severe infections. Significant rootstock by strain interactions were identified through mixed models analysis. We are utilizing this information to breed for durable rootstock resistance to fire blight. However, since it is known that a limited number of apple rootstock genotypes react significantly differently to *E. amylovora* infection as ungrafted potted liners and as rootstocks of flowering orchard trees, the results reported here must be extrapolated to performance in the field with caution.

INTRODUCTION

Fire blight disease is caused by *Erwinia amylovora*, an anaerobic, gram-negative bacterium and its effects can be identified in blossoms, shoots and woody tissue of apple and pear. This bacterial disease was widely spread throughout North America in the 1900's (Aldwinckle and Beer, 1979) and has now spread to Europe and other parts of the world (Jock et al., 2002). The rootstock phase of the disease can be devastating as the bacteria that reach a susceptible rootstock have the ability to multiply and cause necrosis that will girdle the rootstock crown and kill the whole tree. Unfortunately as the disease spreads, its devastating effect is compounded by the widespread use of highly susceptible dwarfing rootstocks ('Malling 9' and 'Malling 26') which are preferred over others because of their ability to increase productivity of high density orchards. The infection of

a rootstock can occur in young shoots of rootstock suckers or blossoms followed by internal movement of the bacteria to the rootstock (Momol et al., 1998). Infection of the rootstock probably can also occur from wounds caused by boring insects. Rootstocks infected with *E. amylovora* often exude translucent ooze that dries to a shiny dark sheen on the surface of the rootstock crown. Streptomycin sprays can prevent the blossom blight phase of the disease in the scion and may therefore reduce the incidence of the rootstock phase but they are not an effective control of rootstock infection (Norelli et al., 2003). Genetic resistance to bacterial diseases has been observed in higher plants, and in this case resistance to *E. amylovora* has been observed in wild apple species and some cultivated varieties (Aldwinckle, 1974; Aldwinckle et al., 1974; Forsline et al., 2002; Gardner, 1977). Apple rootstocks genetically resistant to fire blight are being developed and characterized in Geneva, NY (Gardner et al., 1980). Apple rootstocks, 'G.65', 'G.11', 'G.30', and 'G.16' have been developed through conventional breeding using wild species such as *Malus* x *robusta* cultivar 'Robusta 5' or *Malus floribunda* as one of the parents. These two wild species had been identified as being highly resistant to *E. amylovora* strain Ea273. 'Robusta 5' was later challenged with a highly virulent strain (E4001a) isolated in Canada and identified as moderately susceptible to that strain (Norelli et al., 1986). Two other strains of *E. amylovora*, E2001a and E2017a, have been used in inoculation experiments with various rootstocks and produced differing results (Norelli et al., 2002). The purpose of the present research was to determine the resistance or susceptibility of various apple rootstocks including 'Malling', 'Geneva®', and advanced selections from the Geneva breeding program to each of the four isolates of the causal bacteria *E. amylovora* (E2001a, E4001a, E2017a, Ea273). This study also identified differential susceptibility of these rootstocks to the different strains of *E. amylovora*. The results obtained in this study will be used in combination with molecular genetic techniques to investigate the genetic inheritance of resistance and identify DNA markers linked to the resistance genes to *E. amylovora*. These markers will then be used to select for resistance in apple varieties.

MATERIALS AND METHODS

Bacterial Isolates

Four strains of *E. amylovora*, E4001a, E2001a, E2017a, and Ea273 were grown in Kado broth at 28°C. These cultures were then diluted with 0.05 M potassium phosphate, pH 6.5. The solutions were placed on ice and used for inoculation in the greenhouse within 2 hours of the dilution (Norelli et al., 2002).

Greenhouse Inoculation

Rooted apple rootstock liners of 24 different rootstock varieties were planted in bullet tubes in a greenhouse at the Geneva Experiment Station (NY), and trained to a single vigorously growing shoot. Four sets of 15 liners (one set for each strain tested) were randomized and inoculated according to published protocols (Norelli et al., 2002). Briefly, rootstock inoculations were performed on specimens that had healthy, actively growing shoots. Scissors were dipped into the bacteria suspension and used to cut the tips of soft young leaves close to the apical meristem, dipping the scissors into the bacterial culture between each cut. Percent lesion length (ratio between the length of the necrotic lesion caused by the infection and the overall length of the primary shoot of the rootstock) was recorded 4-5 weeks after inoculation. The length of the lesion was observed by cutting the outer epidermal layer of the branch until a clear boundary between the healthy green tissue and brownish discolored infected tissue became visible. Percent lesion data were analyzed using the PROX MIXED procedure of the SAS system software. Least square means were calculated for main effects (Rootstock and Isolate) and interactions (Rootstock x Isolate).

DISCUSSION

Differential susceptibility of some of the 'Geneva®' rootstocks as described by Norelli et al. (2003) was confirmed. The results summarized in Fig. 1 show that some 'Geneva®' rootstocks are resistant to Ea273 and E2017a and more susceptible to strains E2002a and E4001a. This is probably because the original seedling inoculations used to select these rootstocks used Ea273 as the principal inoculum. Interestingly the rootstocks 'Geneva® 3041' ('M.27' x 'R.5') and 'Geneva® 5179' ('O.3' x 'R.5') show virtually full resistance to all strains tested even the strains reported to overcome the resistant parent ('R.5'), evidence of transgressive segregation of the resistance in that cross with elements coming from both parents ('M.27' and 'R.5'). Although Gardner (1977) described fire blight resistance as a quantitative character further work needs to be performed to elucidate the resistance to fire blight in other apple species and to discover new sources of resistance in exotic germplasm (Forsline et al., 2002). Although the results of this inoculation experiment provide some putative evidence of the resistance of rootstocks, the true test of resistance of an apple rootstock is performed in the field with natural or artificial inoculation of finished trees (Norelli et al., 2002; Robinson et al., 1999). Several experiments with finished trees are currently being performed in Geneva, NY and will provide more definite answers about the field resistance of apple rootstocks (LoGiudice and Aldwinckle, pers. commun.).

Literature Cited

Aldwinckle, H.S. 1974. Field susceptibility of 46 apple cultivars to fire blight. Plant Dis. Reptr. 58:819-821.

Aldwinckle, H.S., Cummins, J.N., Antoszewski, R., Harrison, L. and Zych, C.C. 1974. Inheritance of fire blight susceptibility in some apple rootstock families. Proc. XIX Intl. Horticultural Congress, IA. Section VII. Fruits. p.309 339: [Abstracts]. 1974, 329. ISHS, Warsaw, Poland.

Aldwinckle, H.S. and Beer, S.V. 1979. Fire blight and its control. Hort. Reviews 1:423-474.

Forsline, P.L., Aldwinckle, H.S., Hale, C. and Mitchell, R. 2002. Natural occurrence of fire blight in USDA apple germplasm collection after 10 years of observation. Acta Hort. 590:351-357.

Gardner, R.G. 1977. Breeding apple rootstocks resistant to fire blight. Dissertation Abstracts Intl. B 38:986B.

Gardner, R.G., Cummins, J.N. and Aldwinckle, H.S. 1980. Fire blight resistance in the Geneva apple rootstock breeding program. J. Amer. Soc. Hort. Sci. 105:907-912.

Jock, S., Donat, V., Lopez, M.M., Bazzi, C. and Geider, K. 2002. Following spread of fire blight in Western, Central and Southern Europe by molecular differentiation of *Erwinia amylovora* strains with PFGE analysis. Environ. Microbiol. 4:106-114.

Momol, M.T., Norelli, J.L., Piccioni, D.E., Momol, E.A., Gustafson, H.L., Cummins, J.N. and Aldwinckle, H.S. 1998. Internal movement of *Erwinia amylovora* through symptomless apple scion tissues into the rootstock. Plant Dis. 82:646-650.

Norelli, J.L., Aldwinckle, H.S. and Beer, S.V. 1986. Differential susceptibility of *Malus* spp. cultivars Robusta 5, Novole, and Ottawa 523 to *Erwinia amylovora*. Plant Dis. 70:1017-1019.

Norelli, J.L., Holleran, H.T., Johnson, W.C., Robinson, T.L. and Aldwinckle, H.S. 2003. Resistance of Geneva and other apple rootstocks to *Erwinia amylovora*. Plant Dis. 87:26-32.

Norelli, J.L., Aldwinckle, H.S., Holleran, H.T., Robinson, T.L., Johnson, W.C., Hale, C. and Mitchell, R. 2002. Resistance of 'Geneva' apple rootstocks to *Erwinia amylovora* when grown as potted plants and orchard trees. Acta Hort. 590:359-362.

Robinson, T.L., Cummins, J.N., Hoying, S.A., Johnson, W.C., Aldwinckle, H.S. and Norelli, J.L. 1999. Orchard performance of fire blight-resistant Geneva apple rootstocks. Acta Hort. 489:287-294.

Figures

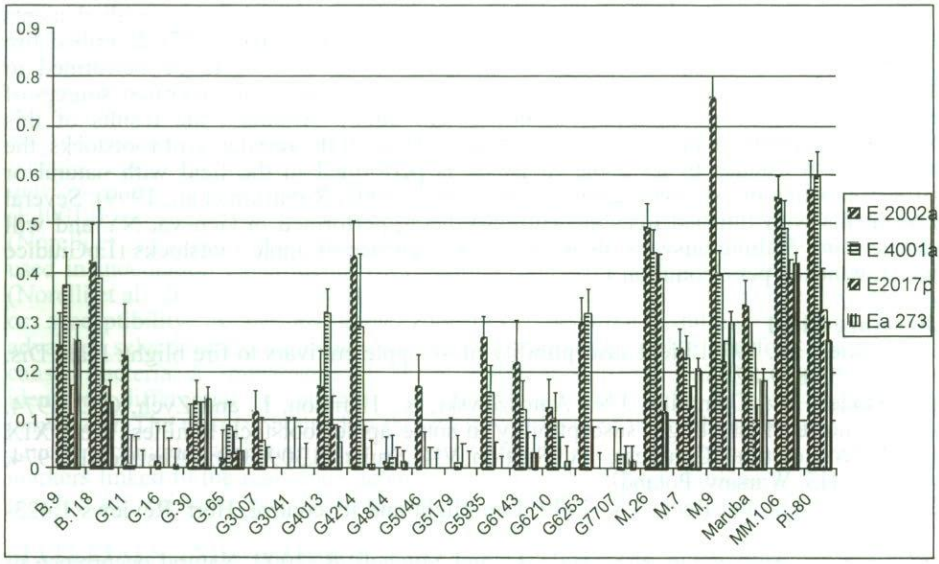

Fig. 1. Means of proportionate necrotic lesion lengths (cm lesion/cm shoot) for several commercial and experimental apple rootstock lines.